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## (54) Actuator control of a flow control valve by its characteristic curve.

(57) A system for controlling the actuator of a flow control valve in which the measured pressure drop $\Delta p$ across the valve and the set flow rate $Q_s$ are fed to a functional block which executes the relationship $\sqrt{\Delta p_o}.Q_s/\sqrt{\Delta p} = C_{vs}$, where $\Delta p_o$ is the constant pressure drop across the valve used to determine its characteristic curve of $C_v$ as a function of the different valve plug positions, said value $C_{vs}$ being fed to another functional block which transduces it into a positioning value for said valve plug in accordance with said characteristic curve, and with which said valve actuator is controlled.

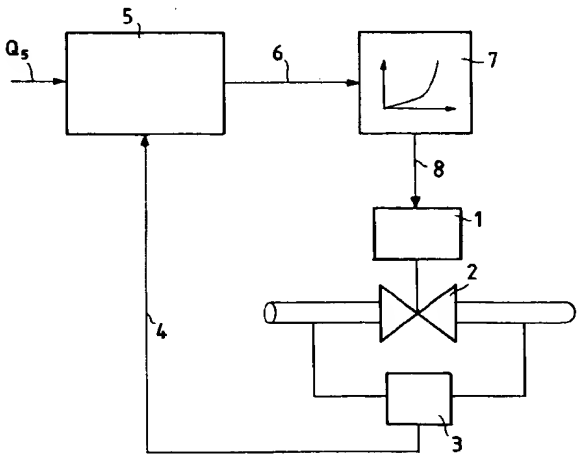


Fig.1

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This invention relates to a new system for controlling the actuator of a flow control valve which does not use a conventional controller requiring appropriate setting of operational parameters variable from one operating condition to another, and hence results in prompt and precise flow control without hunting or delay, independently of operating conditions.

As is known from the state of the art, valve flow control is usually effected by controlling the valve actuator with a positioning command produced by a control unit generally of P.I.D. type, which operates on the error between the set flow value and the effective flow value $Q_m$ measured traditionally by a differential pressure sensor connected to the two terminals of an orifice plate and a square root extractor, using the formula $Q_m = AK\sqrt{\Delta p}$, where A is the cross-sectional area of the sized orifice of the plate,K is a characteristic constant of the plate and $\Delta p$ is the pressure drop across the orifice plate.

This known control system suffers however from drawbacks, the main drawback being the presence of the P.I.D. controller, which besides generating hunting of the variable (flow rate) to be controlled or delay in adjusting the flow rate to the set value if the set operating parameters do not already coincide, also requires continuous adjustment of said operating parameters as the dynamic response of the process varies. A further drawback is the narrow range within which the flow rate can be controlled, this being determined by the operational limits of the orifice plate, the presence, installation and connection of which represents a further drawback which influences the overall cost and size of the system.

These latter drawbacks are obviated in another known system in which the effective flow rate $Q_m$ is determined again by measuring a pressure difference $\Delta p$, but in this case that across the control valve itself, using the characteristic curve for the valve which gives the values of $C_v$ as a function of the position of the valve plug when a certain pressure drop $\Delta p_o$ is present across it, $C_v$ being defined as the flow rate through the valve with a standard constant pressure drop $\Delta p_o$ across it. More specifically, the flow rate $Q_m$ is now determined by a logic unit the inputs of which receive a value representing the pressure drop across the valve and a value representing the position of the valve plug respectively, the unit then calculating the value from the relationship:

$$Q_m = \frac{C_v\sqrt{\Delta p}}{\sqrt{\Delta p_o}} \qquad (1)$$

where the value of $C_v$ is taken from said characteristic curve at the said value representing the valve plug position. Such value of $Q_m$ is then compared with the required or set flow rate by a control unit of P.I.D. type, which provides at its output a new positioning command for the valve actuator.

However, this second system still has all the drawbacks relative to the presence of the P.I.D. controller.

The object of the present invention is to obviate the aforesaid drawbacks by providing a system for controlling the actuator of a flow control valve which acts directly without hunting or delay, and in particular independently of the operating conditions.

This is substantially attained in that the positioning command for the actuator of the flow control valve is obtained from the valve characteristic curve at that $C_v$ value corresponding to the set flow rate, said curve not varying as the valve operating conditions vary.

In other words, as the flow rate Q through the valve and its $C_v$ are related by a relationship of type (1), then:

$$C_v = \frac{\sqrt{\Delta p_o}.Q}{\sqrt{\Delta p}}$$

For each set flow rate $Q_s$ there is therefore a precise value $C_{vs}$ which can be easily calculated from said relationship, knowing the pressure drop $\Delta p$ across the valve; knowing this value $C_{vs}$, the specific value of the positioning command to be fed to the actuator to achieve a flow rate $Q_s$ through the valve can be immediately obtained from the valve characteristic curve.

In this manner the set flow rate is no longer achieved by comparison by means of a P.I.D. controller, but instead is achieved directly.

Hence, the system for controlling the actuator of a flow control valve, comprising a differential pressure sensor measuring the pressure drop across said valve and an operational unit for providing a positioning command to said actuator, is characterised according to the present invention in that said operational unit consists of a functional block, to the inputs of which there are fed the differential pressure value $\Delta p$ measured by said sensor and the set flow rate value $Q_s$, said block executing the relationship $\sqrt{\Delta p_o}.Q_s/\sqrt{\Delta p} = C_{vs}$, where $\Delta p_o$ is the standard constant pressure drop across the valve with which the valve characteristic curve was determined, ie the variation in the valve $C_v$ for the various valve plug positions, its output being connected to a second functional block act-

ing as a transducer for said characteristic curve, to hence provide at its output the positioning command for the valve plug corresponding to said value $C_{vs}$, said command being fed to said actuator.

The invention will be more apparent with reference to the accompanying drawing, which illustrates a preferred embodiment thereof by way of non-limiting example in that technical, constructional or applicational modifications can be made thereto without leaving the scope of the present invention. For example, instead of controlling a liquid-phase flow rate, for which the aforegoing is valid, a gaseous-phase flow rate could be controlled, in which case it is necessary merely to replace said first functional block, which converts the set flow rate value $Q_s$ into a corresponding $C_{vs}$ value, with a new functional block which effects said conversion for gas, ie by also taking into account the pressure, temperature and type of gas in accordance with standard known relationships.

In said drawing:

Figure 1 shows a block diagram of the system for controlling the actuator of a flow control valve, formed in accordance with the invention;

Figure 2 shows the characteristic curve of said valve, ie the variation in the valve $C_v$ with the valve plug position for a constant pressure drop $\Delta p_o$ across the valve.

In the figures, the reference numeral 1 indicates the actuator of the flow control valve 2, across which there is connected a sensor 3 for measuring the pressure drop $\Delta p$ across said valve. The output of said sensor 3 is connected via the connection 4 to the input of a first functional block 5, to which the set flow rate value $Q_s$ is also fed.

Said functional block 5 processes said input values in accordance with the relationship $\sqrt{\Delta p_o}.Q_s/\sqrt{\Delta p}$, where $\Delta p_o$ represents the constant pressure drop across the valve, to determine its characteristic curve 7' shown in Figure 2, ie the variation in the valve $C_v$ with the valve plug positions.

At the output 6 of the functional block 5 there is therefore a value $C_{vs}$ corresponding to the flow rate $Q_s$ for the pressure drop $\Delta p$, this value then being fed to the second functional block 7 in which the valve characteristic curve 7' is stored, so that at the output 8 of said block 7 there is a value $S_s$ corresponding to said value $C_{vs}$ (see specifically Figure 2), ie substantially the position which the valve actuator has to assume to ensure that the value $C_{vs}$ and hence the flow rate $Q_s$ are achieved. The actuator 1 of the valve 2 is then positioned using said value $S_s$.

## Claims

1. A system for controlling the actuator of a flow control valve, comprising a differential pressure sensor measuring the pressure drop across said valve and an operational unit for providing a positioning command to said actuator, characterised in that said operational unit consists of a functional block, to the inputs of which there are fed the differential pressure value $\Delta p$ measured by said sensor and the set flow rate value $Q_s$, said block executing the relationship $\sqrt{\Delta p_o}.Q_s/\sqrt{\Delta p} = C_{vs}$, where $\Delta p_o$ is the standard constant pressure drop across the valve with which the valve characteristic curve was determined, ie the variation in the valve $C_v$ for the various valve plug positions, its output being connected to a second functional block acting as a transducer for said characteristic curve, to hence provide at its output the positioning command for said valve plug corresponding to said value $C_{vs}$, said command being fed to said actuator.

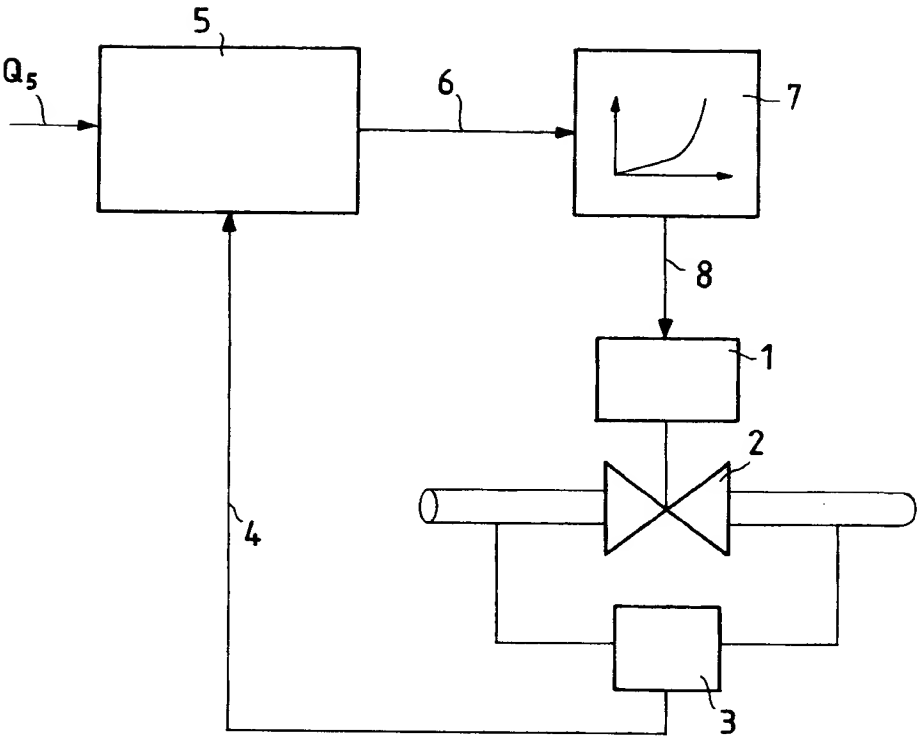


Fig.1

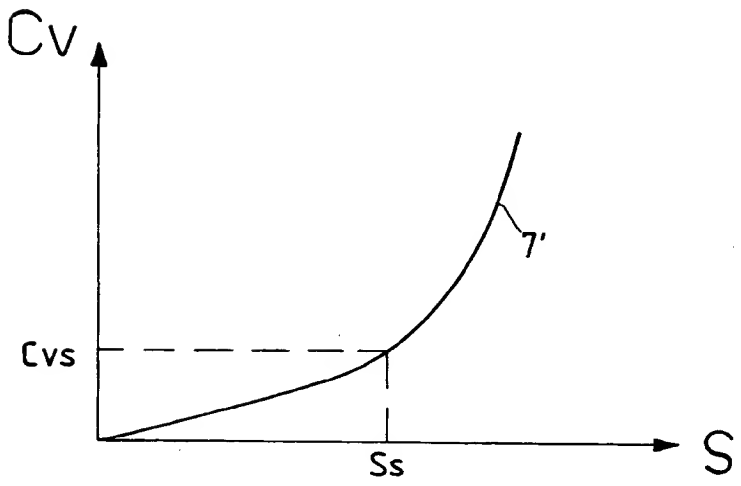


Fig.2

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# EUROPEAN SEARCH REPORT

Application Number

EP 92 20 3140



## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (Int. Cl.5) |
|---|---|---|---|
| X | GB-A-2 123 983 (DELTA TECHNICAL SERVICES LTD)<br>* entire document * | 1 | G05D7/06<br>G05B5/01 |
| P,X | DE-A-4 019 503 (THEODOR HEIMEIER METALLWERK KG)<br>* entire document * | 1 | |
| P,X | EP-A-0 462 432 (VALTEK INCORPORATED)<br>* abstract; column 8, line 55 - column 10, line 50; claims 1, 2, 4, 6, 7 - 12; figures 1, 2, 5, 6 * | 1 | |
| X | US-A-4 277 832 (TH. Y. WONG)<br>* abstract; column 3, line 3 - column 6, line 10; column 7, line 46 - column 8, line 55; figures 1, 2, 4 * | 1 | |
| A | FR-A-2 609 519 (HERION-WERKE KG.)<br>* abstract; page 2, line 30 - page 4, line 26; figures 1, 2 * | 1 | TECHNICAL FIELDS SEARCHED (Int. Cl.5) |
| A | DE-A-3 931 962 (MANNESMANN REXROTH GMBH)<br>* column 1, line 3 - column 2, line 5; column 2, line 26 - column 3, line 30; column 4, line 60 - column 5, line 5; claims 1 - 4; figures 1 - 3, 11 * | 1 | G05D<br>G05B |
| A | CH-A-638 279 (CONTRAVES AG)<br>* abstract; page 2, righthand column, line 26 - page 3, lefthand column, line 27; page 3, righthand column, line 15 - page 4, lefthand column, line 8; figures 1, 2 * | 1 | |

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The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| BERLIN | 12 JANUARY 1993 | BEITNER M. |

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Application Number

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## DOCUMENTS CONSIDERED TO BE RELEVANT

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|---|---|---|---|
| A | PATENT ABSTRACTS OF JAPAN<br>vol. 4, no. 80 (M-015)10 June 1980<br>& JP-A-55 040 363 ( MITSUBISHI HEAVY IND LTD ) 21 March 1980<br>* abstract *<br>----- | 1 | |
| | | | TECHNICAL FIELDS SEARCHED (Int. Cl.5) |

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| BERLIN | 12 JANUARY 1993 | BEITNER M. |

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